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Lake H. Barrett, Acting Director, Civilian Radioactive Waste Management,
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FOREIGN TRIP REPORT

Enclosed please find the report for travel to Spain, Finland, and Sweden by Robert Levich, during the period October 2-17, 1992. If any recipient is interested in a copy of any listed enclosure or any other information related to the enclosed report, please contact Robert A. Levich at (702) 794-7946.

for Carl P. Gertz
Project Manager

YMP:RAL-2115

Enclosures w/Foreign Trip Report:
1. Copies of Program, Participant List, and Presentations at Alligator Rivers Analogue Project Workshop and 5th Natural Analogue Working Group Meeting in Toledo, Spain
2. Copies of Teollisuuden Voima Oy Brochures Concerning Finland's Nuclear Waste Programs and the VLJ Repository
3. Copies of Final Program and Participant List From Fourth International Symposium on the OECD/NEA Stripa Project
4. Executive Summaries of Alligator Rivers Analogue Project Final Reports

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cc w/Foreign Trip Report w/encls:
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FOREIGN TRIP REPORT

Name: Robert A. Levich

Affiliation: Yucca Mountain Site Characterization Project Office, Las Vegas, NV

Dates: October 2-17, 1992

Destination: Spain, Finland, Sweden

Purpose:

1. To represent the U.S. Department of Energy (USDOE) and the Yucca Mountain Site Characterization Project (YMP) at the Alligator Rivers Analogue Project (ARAP) Workshop and the 5th Meeting of the Commission of the European Communities (CEC) Natural Analogue Working Group (NAWG 5) in Toledo, Spain.

2. To attend the final meeting of the Joint Technical Committee (JTC) of the ARAP at the Beatriz Hotel in Toledo, Spain

3. To discuss and evaluate a proposed new project at Koongara, Northern Territory, Australia (or an extension of ARAP) and possible future participation by USDOE, along with representatives of the U.S. Nuclear Regulatory Commission (USNRC), the Australian Nuclear Science and Technology Organization (ANSTO), the Swedish Nuclear Power Inspectorate (SKI), Japan's Central Research Institute of Electric Power Industry (CRIEPI), the Japan Atomic Energy Research Institute (JAERI), and Japan's Power Reactor and Nuclear Fuel Development Corporation (PNC).

4. To transfer information and related technology concerning natural analogue studies, the development and management of natural analogue programs, and results and progress of studies conducted at Koongara in the Alligator Rivers District (Australia), and other international locales to the Office of Civilian Radioactive Waste Management (OCRWM) and the YMP.

5. To discuss current and future natural analogue projects including Alligator Rivers, Cigar Lake (Saskatchewan, Canada), Oklo (Gabon, equatorial Africa), and other proposed projects including Santorini (Greece), Peña Blanca (Chihuahua, Mexico) and others with technical managers and scientists proposing or developing these studies.

6. To attend and represent the United States (U.S.) at the final meeting of the JTC of the OECD/NEA International Stripa Project. The Stripa JTC meeting was held in several localities in Finland and Sweden.

7. To attend and serve as Chairman of a technical session at the Fourth (and final) International Symposium on the OECD/NEA Stripa Project in Stockholm, Sweden.

8. To visit the completed VLJ repository for low- and intemediate-level wastes of Teollisuuden Voima Oy (TVO) at Olkiluoto, Finland.

Commitments:

1. I committed to the ARAP/JTC that DOE would be responsible for distributing up to fifty copies each of the 16 final technical ARAP reports developed by the scientists investigating the Koongara site.

2. I gave a commitment to representatives from Australia (ANSTO), Japan (CRIEPI, JAERI & PNC), Sweden (SKI) and the USNRC that USDOE would evaluate participation in a limited extension of the ARAP. USDOE will consider supporting continuing studies by scientists from Los Alamos National Laboratory (LANL) and Battelle Pacific Northwest Laboratories (PNL) and possible new studies by scientists from Lawrence Livermore National Laboratory (LLNL).

3. I committed to USDOE completing a final review of the Stripa Project Overview Reports by early December, 1992.

4. I committed to exploring the possibility of the U.S. serving as the site for the 1994 meeting of NAWG. Dave Curtis, LANL, volunteered to host and organize the NAWG 6 meeting in northern New Mexico, in or near Santa Fe during mid-1994.

5. I committed to send Hideki Sakuma, PNC, Japan, a copy of the Yucca Mountain Site Characterization Project Bibliography.

Recommendations:

1. I recommend that USDOE should consider becoming a participant in any future extension of the studies of Koongara, however, the priority of this participation should be carefully evaluated against other alternatives.

2. USDOE should continue to fund the studies of Koongara samples and measurements of naturally occurring Pu and other radionuclides by Dave Curtis and his staff at LANL to the amount of $100K per annum.

3. I recommend that USDOE should join the CEA and other participants in the CEC-supported geoscientific studies at the Oklo natural reactors site in Gabon, equatorial Africa, by sponsoring and funding the proposed studies by Dave Curtis (LANL) and Bill Glassley (LLNL).

4. I recommend that the USDOE and the Yucca Mountain Project meet with USNRC staff to discuss possible participation in the Peña Blanca natural analogue study in Chihuahua, Mexico, and evaluate developing and sponsoring it as an international natural analogue project to study migration and transport of radionuclides in unsaturated tuffaceous volcanic rocks. Participation by foreign scientists will provide expertise gained in planning and implementing studies at Poços de Caldas, Alligator Rivers, Oklo, and other locales.

5. I recommend that OCRWM support both conceptually and financially LANL acting as hosts, in northern New Mexico, for the 1994 NAWG meeting.

6. I recommend that OCRWM pursue closer relations with PNC of Japan and explore possible areas of technical cooperation between the two programs.

Description of Travel Activities:

I. ARAP WORKSHOP AND NAWG 5 MEETING

The meeting and workshop was held at the Hotel Beatriz in Toledo, Spain, and was a well-attended and well organized six day event. It was attended by more than 80 prominent scientists and technical managers from around the world representing twelve countries and two multinational agencies. The single most important part of the meeting consisted of the two day ARAP workshop which provided the world nuclear waste community with a summary of the wealth of technical research represented by the project. There is no question that the quality of the technical work at Koongara was of extremely high quality, and every bit as good as that of other natural analogue research programs. Unfortunately, however, the ARAP Final Workshop presentations were not as cohesively organized and presented as those of the Final Workshop for highly-praised Poços de Caldas Project, which were presented in June 1990 at the NAWG 4 Meeting in Pitlochry, Scotland. The ARAP Final Workshop took place on Monday and Tuesday, 5th-6th, October, and consisted of 21 papers:

1. Introduction, P. Duerden, Australia
2. Performance Assessment and Validation Aspects of the Alligator Rivers Analogue Project, S. Wingfors, Sweden
3. Geology/Geomorphology, K-H Wyroll, Australia
4. Site Characterization with Respect to Groundwater Flow, D.W. Emerson, Australia
5. Borehole TV Mapping in the Vicinity of the Koongara Uranium Ore Deposit, K. Miyakawa, Japan
6. Hydrogeology of the Koongara Site, S.N. Davis, USA
7. Hydrological Modelling, L. Townley, Australia
8. Evidence for Fracture Flow and Preliminary Discrete Fracture Analysis of the Alligator River Natural Analogue, J.L. Smoot, USA
9. The Chemistry and Isotopic Composition of Koongara Groundwaters, T.E. Payne, Australia
10. A Study of Colloids in Groundwaters at the Koongara Uranium Deposit, T. Seo, Japan, R. Edis & T.E. Payne, Australia
11. Solid Phase Studies and Uranium Distribution at Koongara, R. Edis, Australia
12. Uranium Ore Bodies as Source Terms for Radionuclides: Measurements and Models, J. Fabryka-Martin and D.B. Curtis, USA
13. Mineral Alteration and Uranium-Associations, T. Murakami, Japan
14. Uranium Sorption, T.D. Waite, Australia
15. Geochemistry-Groundwater Speciation, Modelling, D. Sverjensky, USA
16. Chemical Modelling - Formation of Ore Zones, D. Sverjensky, USA
17. Development of Secondary Uranium Mineralogy at Koongara: Implications with Respect to Uncertainty in Geochemical Data, D.G. Bennett & D. Read, UK
18. Transport Modelling, Review of Site Models, C. Golian, Australia & D. Lever, UK
19. Linking Models to Performance Assessment, D. Lever, UK
20. Scenario Development, S. Wingfors, Sweden
21. Have We Accomplished What We Aimed To Do, and Where Do We Go From Here?, L.A. Kovach and G.F. Birchard, USA

The ARAP Final Workshop included excellent discussions of both the scientific studies at Koongara and their results. Highlights of the ARAP Final Workshop follow:

Peter Duerden, ANSTO, Australia, Manager of the ARAP introduced the ARAP:
- First scientific investigations of Alligator Rivers area followed World War II
- Uranium was discovered in 1953
- Four major deposits have been discovered in the area: Ranger, Koongara, Jabiluka and Nabarlek
- Australian Government decided that development will proceed at Ranger and Nabarlek
- Investigations at Koongara began in 1970
- There has been extensive drilling at Koongara (Denison Mines)
- Many boreholes remain open for study
- Focus of Project was radionuclide migration in the near-surface (to 25m depth)

Stig Wingfors, SKI, Sweden, discussed the performance assessment and validation aspects of ARAP:
- Many aspects of PA were covered by ARAP studies
- The variety of issues put demands on ARAP participants to use the vast amount of collected data
- The variety of issues examined leads to confidence-building.

Karl-Heinz Wyroll, University of Western Australia, Australia, made a presentation of the geology and geomorphology of the Koongara site:
- Denudation rates and hydrology at Koongara have been driven over the last few million years by climate
- Neotectonics at Koongara is meaningless
- There have been vast variations in climates in Australia during the last one million years.

Don Emerson, University of Sydney, Australia, discussed site characterization with respect to groundwater flow:
- Shallow geophysics indicates that weathered zone is moderately deep
- 12km of surface geophysical lines have been run at the Koongara site
- An integrated approach was successfully used in characterizing site
- Site characterization included studies of lithology, structure, fabric, void distribution, and fracturing
- Important lithologic and structural features were recognized
- Written paper includes a summary of the physical properties.

Kimio Miyakawa, CRIEPI, Japan, reported on borehole TV mapping of 20 boreholes in the vicinity of Koongara:
- Logged a total of 469m
- Surveyed 931 fractures representing two distinct trends
- Classified the fractures into three distinct types ranging from closed and discontinuous to open.
- Analyzed schistosity orientations revealing a large synform-antiform fold structure.

Stan Davis, University of Arizona, USA, discussed field hydrology measurements at Koongara:
- Water-level, aquifer-test and slug-test data indicate that Koongara uranium deposit lies within a low-permeability, semi-confined, fractured schist
- Direction of maximum hydraulic conductivity is subparallel to lithologic layering and the Koongara fault
- Environmental isotopes and helium indicate isolation from atmosphere for more than 40 years and possibly several thousand years.

Lloyd Townley, CSIRO, Australia, described hydrological modelling of the Koongara site. Why does the Koongara Site have extreme complexity?
- Subsurface flow is a miniscule component of overall water balance
- Flow occurs mainly in fractures rather than in porous media
- Rocks are extremely heterogeneous and are fractured at several different scales
- Boreholes were drilled for the exploration and development of the uranium ore body
- Boreholes were not constructed for groundwater modeling, e.g., there are no holes near Koongara Creek
- At start of project, it was hoped that hydrological modeling would serve as the "integrator" for the project, however it does not!

John Smoot, Battelle PNL, USA, developed simulations of the subsurface hydrology at Koongara based on fracture flow and preliminary discrete fracture analysis:
- Used FracMan-Mesh Monster-Edmesh-Mafic suite of discrete fracture software developed by Golder Associates in Seattle, WA
- Conducted simulations within a cubic domain with 180m edges, containing 500 simulated fractures, a mean fracture radius of 30m length, constant transmissivity and constant head boundaries
- Discrete fracture modeling on field scale is feasible and the availability of data is the limiting factor
- Results were based on a hypothetical fracture network.

Tim Payne, ANSTO, Australia discussed the chemistry and isotopic composition of Koongara groundwaters. For groundwater at depths greater than 16m:
- Mg^+ is the primary cation
- Ca^+, Na^+, Fe^+ and U^+ are secondary cations
- Bicarbonate ($HCO3^-$) is the primary anion
- pH is near neutral
- U and U-series occurs in elevated concentrations
- U varies between 0.1 and 1000 ppb as a function of distance from fault
- Th is extremely mobile
- ^{14}C content increases with distance from fault.

Toshihiro Seo, PNC, Japan, described the study of colloids in groundwaters at the Koongara Uranium Deposit:
- Major colloidal constituents include clay particles, fine quartz grains and Fe-rich particles
- Minor colloidal constituents consist of Ti-rich particles, Pb-rich particles, Au-rich particles, and U-rich particles

- ^{230}Th colloidal content range from 12 to 87%; ^{238}U colloidal content range from 1.1 to 2.5%
- Total ^{238}U = .079 to 40 ppb; Total ^{230}Th content is very much lower.

Robert Edis, ANSTO, Australia presented solid phase studies and uranium distribution at Koongara:
- Phosphorous in unweathered rock: mainly fluroapatite, possibly hydrothermal
- Intensity of weathering decreases with distance from fault
- Fe-oxides: goethite, hematite, ferrihydrite
- Mg-oxide: lithiophorite
- Elements associated with U in weathered zone: P, Pb, Zn, As, Ni, Cr, Ga, Fe
- Unweathered zone: U associated with U-minerals, coatings
- Weathered zone: Uranyl phosphates, Fe-oxides, Mg-oxides, Ti-oxides, Ce-oxides
- U is mainly associated with Fe and Mn (sorption)
- Fe, U adsorption on surfaces
- U migration is linked to the weathering process
- U-series and trace element data is available on discs for anyone who wishes data for modeling

June Fabryka-Martin, LANL, USA, discussed measurements and models of uranium orebodies as source terms for radionuclides:
- U orebodies as spent fuel analogues to set limits of release rates for ^{239}Pu, ^{99}Tc and ^{129}I.
- U orebodies can be used as analogues for release processes, transport processes and radioactive decay
- U deposits sampled and studied: Cigar Lake, Key Lake, Beaverlodge, Poços de Caldas, Shinkolobwe (Katanga), Oklo, Koongara
- Grade of U ore samples range from 7 to 65%
- Dominant production mechanism of ^{129}I in high grade ores is ^{235}U induced fission
- Dominant production mechanism of ^{99}Tc is ^{238}U spontaneous fission
- Possible evidence of loss of ^{99}Tc during weathering
- No evidence of loss of ^{239}Pu from unweathered areas
- Possible evidence for mobility of ^{239}Pu in groundwater

Takashi Murakami, JAERI, Japan, discussed alteration and uranium-associations:
- Weathering of chlorite has affected U redistribution at Koongara
- Abundances of chlorite, vermiculite and kaolinite correspond well to U concentrations
- U concentrations are qualitatively proportional to extent of weathering
- Developed one-dimensional, advection-dispersion-sorption model which considered changes in distribution coefficients and porosities with time resulting from weathering of chlorite.

David Waite, ANSTO, Australia, described uranium sorption measurements and modeling:
- U adsorption and desorption to well defined mineral phases and selected natural substrates was studied
- Single phases include ferrihydrite, crystalline silica and kaolinites
- Results were modeled using surface complexation approach
- Mononuclear uranyl surface species most appropriately described adsorption results.

Dimitri Sverjensky, Johns Hopkins University, USA, presented a paper on the geochemical modelling of groundwaters and speciation.
- Series of aqueous speciation and state of saturation calculations for groundwater compositions
- Aqueous speciation, saturation state and chemical mass transfer calculations used EQ3NR and EQ6 with thermodynamic data base generated at Johns Hopkins
- Weathering of chlorite-bearing schist modified by distinctly acidic rainwater can account for major element chemical variation in Koongara waters
- Very strong depth dependence of all major chemical trends indicates vertical recharge by rainwater progressively evolving chemically by reaction with the chlorite schist

Dimitri Sverjensky, Johns Hopkins University, USA, discussed the geochemical modelling of secondary uranium ore zones.
- Theoretical chemical mass transfer calculations and models were used to investigate and reconstruct the kinds of waters that could produce a uranyl phosphate zone
- Geological and mineralogical data for Koongara weathered zone were used to constrain initial compositions and reactions
- Used EQ3NR and EQ6 with Johns Hopkins thermodynamic data base
- Uranyl phosphate zone at Koongara did not form from present day groundwaters
- Uranyl phosphate zone must have formed in the geologic past under unsaturated conditions
- Base of uranyl phosphate zone may represent a paleo-water table
- Uranyl phosphate zone may have formed in a more arid climate with a water table much lower than at present.

David Bennett, WS Atkins, United Kingdom, described the development of secondary uranium mineralogy of Koongara and implications with respect to uncertainty in geochemical data:
- Aqueous uranyl phosphate species are much less stable than previously thought
- Produced consistent and reliable data for pitchblende
- Data was sparse for uranyl silicate minerals
- Developed 2 models for formation of saleeite (uranyl phosphate) zone:
  - Weathering model
  - Evaporation model
- Developed coupled chemical transport model based on a simplified conceptual model of Koongara, using a one-dimensional numerical code CHEMTARD

Cezary Golian, ANSTO, Australia, discussed transport modelling and reviewed site models:
- Analogue research identifies scenarios:
- Modelling studies identified importance of several retardation mechanisms
- Can investigate order of importance of transport/retardation processes
- Must increase knowledge of system to get more truth from models (otherwise, simple models are best).

David Lever, UKAEA Harwell, United Kingdom, discussed linking models to performance assessment:
- Large number of models used to interpret available database for concentrations of uranium series radionuclides in groundwater and solid phases
- Value is seen in the diversity of modeling approaches
- Models used to investigate a number of effects and the values of different parameters
- Partitioning of uranium into a crystalline phase is an important retarding process to uranium transport

Stig Wingfors, SKI, Sweden, presented a paper on scenario development.
- Applied PA scenario development to the evaluation of Koongara
- Established systematic description of analogue
- Identified 242 FEPs (features, events, processes) at Koongara
  - Process System (used in scenarios): 138 FEPs
  - External Conditions: 39 FEPs
  - External Features: 13 FEPs
  - Screened out: 52 FEPs
- FEPs in Process System were used in the systematic description of the analogue in terms of schematic diagrams
- External Conditions and External Features used to formulate scenarios
- Three major scenarios were developed. Uranyl phosphates formed under:
  - Unsaturated conditions with a periodic evolution of the dispersion fan
  - Unsaturated conditions as a single event
  - Saturated conditions.

Linda Kovach, USNRC, USA, presented a paper asking the questions:
"Have we accomplished what we aimed to do?" and "Where do we go from here?"
The application of natural analogues to the licensing process:
- No validation for natural system; instead, "Reasonable Assurance"
- If we "reduce uncertainty", we "gain confidence"
- Geochemical modelling: Test/develop thermodynamic data bases
- Radionuclide Migration/Retardation: Develop/test mechanistic U sorption models and geochemistry of Pu, Tc and Cl
- Regulatory perspective:
  - Exercise PA teams - No!
  - Identify areas of confidence and weakness - Yes!
  - Integration of disciplines - Yes!
  - Overall integration of project - Maybe?
- Have we achieved what we aimed? - Yes, No, Maybe.
- Where do we go from here? - Continue analogue research!

The NAWG 5 Meeting, opened with a keynote presentation by the former chairman of the NAWG Core Group, Neil Chapman, Intera, UK. The paper was entitled:
"The Role of Natural Analogues".
- Most of the processes of interest take place in the Near Field
- The Far Field is a cocoon that holds the Near Field
- Use information from natural analogues to build confidence in natural system:
  - To which specific R/W issues is work directed?
  - Exactly how is it intended that data will be used? (e.g., PA?)

- Natural analogues are about geochemistry
    - Most useful data concern waste package behavior and mass transport in groundwater
- Applications of natural analogues:
    - Help build models
    - Ensure that models are comprehensive and real
    - Provide data to validate models
    - Use as test beds for models
- Natural analogue studies
    - Uranium ore bodies
        * Speciation and solubility
        * Sorption and matrix diffusion
        * Colloids
        * Composition, stability
    - Hyperalkaline environment
        * Solubilities and speciation of radionuclides at high pH
    - Geochemical discontinuities (in clays)
        * Roles of diffusion, advection and heterogeneities
        * Thermal stabilities of clays
    - Hydrothermal systems
        * Changes in rock physical properties
    - Archaeological analogues
        * Corrosion of metals
        * Long-term evolution of cement properties
        * Decay and breakdown of organic materials
        * Interaction with surrounding rocks - Near Field processes
    - Natural Occurrences of Repository Materials
        * Glasses
        * Native metals and meteorites
        * Wood and bitumen (for low-level waste)
- Role of natural analogues
    - Setting conceptual basis for PA models
    - Probably only 2 parameter values have ever been provided by analogues for direct use in PA:
        * Corrosion pitting factors
        * Matrix diffusion
    - Vital 'soft quantitative' role providing limits to parameter ranges and checking correct range of predictions
    - Test-beds for models
- Analogue spin-offs to site characterization
    - Heterogeneity and sampling problems
    - Sparse data/robust models
    - Bias in conceptual models
    - Complexities often insurmountable
    - Transferability of data
- The PA problem
    - We are using engineering approach to natural systems
    - Quantitative validity of predictions in complex, coupled, non-linear systems
    - Natural systems as 'governors' constraining absolute bounds, directions and reasonableness of predictions

- Building confidence in measurements
  - Acceptance is not as simple as complying with numerical regulations
    * Use 'Expert Judgment' (Do things look right?)
    * Natural analogues as illustrations (factual examples with time contest)
      - Processes are not figments of imagination
      - Time scales are realistic
  - Natural geochemical fluxes: U, Rn, Cd, etc.
  - Paleohydrology
    * Combined groundwater hydrochemistry/isotopic data and rock/mineralogic/isotopic/hydraulic data
    * Compiled to measure evolution of site
  - Simple applications
    * Site suitability
    * Evidence of stability of deep system and high buffering capacity to build confidence
- Where do we go from here?
  - Don't apply term "analogue" too broadly
  - Model testing has high priority
  - Illustrate context for decision-makers
  - Large studies are valuable, but don't forget small limited ones
  - Better presentations of natural analogue material
  - Use natural analogues to support presentation of PA results
  - Use by decision-makers of broader more quantitative criteria in which to judge assessment
  - More emphasis on qualitative and semi-quantitative criteria than rigid quantitative regulations.

The first part of Session 2 of the NAWG, Natural Analogue Studies, was Chaired by Russell Alexander of Nagra, Switzerland on Wednesday morning, 7th October. As representatives from AECL in Canada were unable to attend, John Smellie, Conterra, Sweden, described the Cigar Lake analogue project in Saskatchewan, Canada:

- Uranium ore deposit partially underlies Cigar Lake and nearby Waterbury Lake
- Age of deposit is 1.32 billion years
- Average grade is 12% U_3O_8
- Tasks: Geology, mineralogy, geochemistry
- Two reference data bases: Mineralogy; hydrochemistry
- Hydrology: 2D and 3D modeling on regional and local scales
- Three hydrologic regimes:
  - Overburden - 7m/year
  - Middle (permeable sandstone) - 8m/year
  - Deeper (Regolith impermeable?) - 0.003m/year
  - Ore and Clay - 6mm/year
- Hydrochemistry - Na, Ca, (K); HCO_3 $Cl(SO_4)$ and fairly neutral pH away from deposit, but more reducing at deposit.

Paul-Louis Blanc, CEA/IPSN, France, discussed the Oklo as a Natural Analogue Project" which is conducting research in radionuclide transport processes at the Oklo uranium deposit, Gabon, equatorial Africa. He discussed the current status of the programme:

- Current project is concentrating on "new reactors", discovered in 1984.

Julio Astudillo, Enresa, Spain, reported on the El Berrocal project near Toledo, Spain:
- Phase 1
  - Participants: Spain, France, UK, Italy
  - Characterize geology and geochemistry of site to 250m depth
- Phase 2 (1993 - 1995):
  - Integrate and interpret data
  - Collect data to 600m depth
  - Five Subtasks:
    * Site description
    * Geochemical characterization
    * Colloidal transport
    * Uranium migration and distribution
    * Coupled transport modeling.

Toshihiro Seo, PNC, Japan, described natural analogue studies at the Tono uranium deposit in Japan.

Paul Hooker, UKDoE/HMIP, UK, described natural analogue projects in the UK and implications for PA:
- Studied 4 analogue sites in UK: Loch Lomond, Needle's Eye, South Terras (former uranium mine) and Broubster (Scotland)
- All studies were under auspices of UK Natural Analogues Coordinating Group
- To understand migration & behavior of radionuclides & elements in sediments
- To improve modeling capabilities

The second part of Session 2 was chaired by David Read, WS Atkins, UK.

Runar Blomqvist, GTK Espoo, Finland discussed the natural analogue study at Palmottu in southwest Finland:
- Analogue site is U-Th deposit
- Rocks are migmatitic mica gneiss and granite/pegmatite
- 6 Reports are available concerning studies at Palmottu.

Cherry Tweed, UKAEA Harwell, UK, reported the analogue study at Maqarin, Jordan:
- High pH, alkaline environment
- Thermally metamorphosed marls and limestones
- Hyperalkaline springs (pH = 12.5-12.9) has present-day activity
- Spontaneous combustion of bituminous marl
- Microbiology (some completed and some in progress)
- Validation of coupled codes (in progress)
- Refinement of trace element solubility modeling (in progress)
- Characterization of clays and organics (in progress).

Dave Curtis, LANL, USA, discussed natural constraints on radionuclide release:
- Juvenile radionuclide geochemical cycle - parent element is U and daughter elements are Pu, Tc and I.
- Measure radionuclide release rates under a variety of conditions

Bill Murphy, CNWRA/SWRI, USA, discussed the PA significance of natural analogue studies at Peña Blanca, Chihuahua, Mexico and Santorini, Greece:
- Akrotiri analogue site on Santorini is 3.6 X 10^3 years old
- Nopal I deposit at Peña Blanca, Chihuahua is site for USNRC study.

The wrap-up and discussion following Session 2 was lead by session chairmen Russ Alexander and David Read, plus Kirk Nordstrom, USGS, USA.

Session 3, Natural analogue systems: paleohydrology, was held on the morning of Thursday, 8th October and was Chaired by Emmanuel Ledoux, Ecole de Mines, France, who opened the session with a discussion of the paleohydrology of the Mol Clay during glaciation as a possible analogue to the Paris Basin.

Grant Garven, Johns Hopkins University, USA, presented a hydrogeologic analysis of uranium ore formation in Proterozoic sedimentary basins (e.g., Athabaska Basin in Saskatchewan, Canada):
- Hydrologic characteristics of unconformity-type deposits
- 1350-1050 Ma B.P.
- Formed by saline waters (brines) at temperatures of ca. 200° C.
- Hydrologic systems for Proterozoic Basins: (1) Thermally-driven free convection; (2) Topographically-driven; (3) Intrusive of metamorphic waters
- Used finite-element model of basin

Jean-Charles Fontes, Université de Paris Sud, France, discussed isotope paleohydrological constraints on groundwater movements in low permeability rocks:
- Paleohydrological reconstructions obtained from environmental isotopes can provide a unique set of constraints to assess long-term hydrology.

Adrian Bath, British Geological Survey, United Kingdom, described evolution of pore waters in mudrocks.

Bill Glassley, LLNL, USA described the proposed project for validation for PA if hydrochemical codes using the New Zealand geothermal system.
- Selected the high sulfur Rotokwa Geothermal Field as a test case (It is not intended that the Rotokwa Geothermal Field serve as a permanent site.)

Session 4, Natural analogues, a Wider Perspective, was held in the late morning and early afternoon of Thursday, 8th October and was Chaired by Jean-Claude Petit, CEA, France.

William Miller, Intera, UK, presented a reviewed the development of natural analogue studies and their application to PA:
- Repository materials - Positive information
  - Corrosion rates of metals/pitting factors
  - Dissolution rate of uraninite
  - Smectite to illite transformation rate
  - Longevity rate of CSH compounds in cements
  - Dissolution rate of glass
  - Hydraulic barrier function of clays (and bitumen)

- Repository materials - Further studies
  - Direct incorporation of radionuclides into waste-form (glass, spent fuel), alternative phases
  - Hydrogen production from Fe corrosion
  - Cementation of bentonite
  - Bentonite (and cement) pore water evolution
  - Interaction between different waste-forms/materials/rocks
- Release/transport processes - Positive information
  - Matrix diffusion in fractured rocks
  - Transport/retardation processes in fractured rocks
  - Redox front processes
  - Diffusion in clays
  - Colloidal populations in deep groundwater
  - Microbiological population in hyperalkaline environments
  - Testing/validation of thermodynamic soluability-speciation codes and data bases
- Release/transport processes - Areas for further studies
  - Better in situ K_d methods
  - Colloidal migration in Far Field
  - Redox front processes in sediments
  - Matrix diffusion in sedimentary rocks
  - Further radiolysis studies
  - Matrix diffusion controls on fractured rock redox buffer capacity
  - Radionuclide transport processes in anhydrite
  - Radionuclide transfer processes at geosphere-biosphere interface
  - Far Field gas migration
- Methodology: Modeling-Laboratory studies-Analogues: All 3 are interlinked.

Jack Daemen, University of Nevada-Reno, USA, discussed gas pressure build-up, host-rock mechanics, and possible implications for the performance and PA of a high level nuclear waste repository.

Ferruccio Gera, Ismes, Italy, discussed magmatic intrusions in clays as geomechanical-natural analogues.

The paper by Geoffrey Boulton, University of Edinburgh, UK, on natural analogues for large scale overpressured groundwater movements beneath glaciers was canceled.

Robert Muir-Wood, BEQE, UK, discussed natural analogues and neotectonics:
- Active fault hydrology: normal, reverse, strike-slip
- Current hydrology: springs, subsurface fluid conduits, channeling
- Paleohydrology: veins/fractures, faults, fluids
- Dynamic hydrology: cycles, transient features, permanent change.

Jacques Boulègue, Université de Paris VI, France, discussed the geochemistry of ore deposits: reservoirs, leaks and sinks.

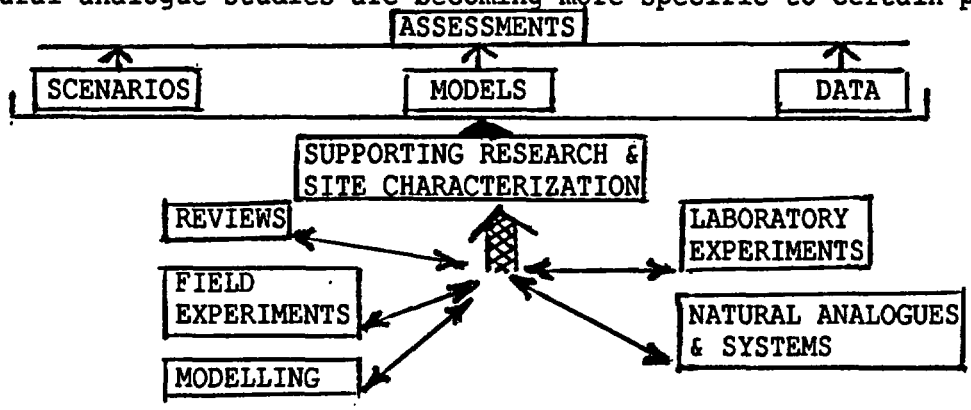
The NAWG 5 Meeting concluded with Session 5, a Panel dealing with the question: "Why don't we see more recognition of natural analogues in PA?" The members of the Concluding Panel were:

Ian McKinley, Nagra, Switzerland, Chairman
Jordi Bruno, MBT, Spain
Norm Eisenberg, USNRC, USA
David Lever, UKAEA Harwell, UK
Ivars Neretnieks, KTH, Sweden

Norm Eisenberg:
- Why aren't natural analogues used more by PA?
  - Different focus of investigations and investigators
    - Different concept of model
    - Deterministic vs. probabilistic
    - Precise vs. coarse
  - Organization constraints
    - Different departments, responsibilities, budget
    - Insufficient coordination
  - Proof of safety by analogue is an important support, but is unlikely to carry the day in licensing
  - Natural analogues provide anecdotal evidence; PAs apply general principles
- What can natural analogues provide to PA?
  - Data and data uncertainties
  - Qualitative conceptualization
  - Support for model validation
  - Insights to limits on site characterization

Ivars Neretnieks:
- Key issues in SKB program:
  - Matrix diffusion
  - Channeling
  - Rate of release from Near Field
  - Radiolysis
  - Redox front
- SKB has built confidence in its model by studies at Poços de Caldas, and have additional possibilities with other analogue studies.

David Lever:
- Analogue studies are becoming more important in U.K.
- Natural analogue studies are becoming more specific to certain processes



- UKNirex analogue studies:

- Jordan	Near Field/Disturbed Zone
- Microbial Populations	Near Field
- Oxidized Disturbed Zones	Disturbed Zone
- Matrix Diffusion	Far Field
- Uranium in natural systems	Far Field
- Colloids	Far Field

Jordi Bruno:
- Natural analogue studies are useful in four levels of safety assessments
  - Definition of the disposal concept and its components
  - Identification of the possible processes and events that may affect integrity of system
  - Quantification of the radiological impact
  - Description of associated uncertainties
- PA is a simplified model based on a number of PA submodels
- Natural analogues can provide confidence on robustness of submodels.

Ivars Neretnieks:
- Natural analogues must be used for larger space scales, longer time scales, and robustness. We cannot do without them!

The following papers were presented at a Poster Session:
Linda Kovach, USNRC, USA, "USNRC Natural Analogue Research Programme".
John Smellie, Conterra, Sweden & Fred Karlsson, SKB, Sweden, "Use of Natural Analogues in Swedish Repository Performance Assessment".
S.M. Pate, Russ Alexander, University of Bern, Switzerland & Ian McKinley, Nagra, Switzerland, "Use of natural analogue test cases to evaluate a new performance assessment Technical Data Base".
Karl-Heinz Hellmuth, Finnish Center for Radioactive & Nuclear Safety, Finland, "Natural analogue study on native iron" and "High-FeO olivine rock, a potential redox-active backfill material working in a natural-analogue way".
Toshihiko Ohnuki, JAERI, Japan, "Fractionation of uranium between minerals by rock weathering".
John Smoot, PNL, USA, "3-D Discrete fracture model of Koongara uranium ore body".
Modesto Montoto, University of Oviedo, Spain, "Microfractography of El Berrocal granite".
Stan Davis, University of Arizona, USA, "Field hydrology measurements (ARAP)".
Heikki Kumpulainen, Technical Research Centre, Finland, "Element mobility in rock matrix at Palmottu".
Rikje van de Weerd & Melissa Richardson-van der Poel, RIVM, Netherlands, "Modelling of uranium transport at Koongara with a moving weathered zone".

II. ALLIGATOR RIVER ANALOGUE PROJECT JOINT TECHNICAL (JTC) COMMITTEE MEETING

The final meeting of the ARAP-JTC took place at the Hotel Beatriz during the NAWG meeting. It was attended by representatives of all the sponsoring organizations: ANSTO (Australia), HMIP/UKDoE (UK), JAERI (Japan), PNC (Japan), SKI (Sweden), USNRC (USA) and USDOE (USA).

Peter Duerden, ANSTO, Manager of ARAP reported that most ARAP final reports were 95% completed and all were in their final stages of completion. Drafts of 15 of the 16 final reports were available in Toledo for examination by NAWG Workshop attendees (and were also distributed to the members of the ARAP/JTC). I have copies of these drafts and interested parties may obtain copies by contacting me in Las Vegas. The final volumes will be printed in 1993. Any parties interested in obtaining a complete set of these volumes should also contact me. The draft volumes are as follows:

1. Summary of Findings, P. Duerden, D.A. Lever, D.A. Sverjensky and L. R. Townley.
2. Geologic Setting, A. A. Snelling.
3. Geomorphology and Paleoclimatic History, K-H Wyroll.
4. Geophysics, Petrophysics and Structure, D. W. Emerson.
5. Hydrogeological Field Studies, S. N. Davis.
6. Hydrogeological Modelling, L. R. Townley.
7. Groundwater Chemistry, T. E. Payne.
8. Chemistry and Mineralogy of Rocks and Soils, R. Edis.
9. Weathering and its Effects on Uranium Redistribution, T. Murakami.
10. Geochemical Data Bases, D. G. Bennett and D. Read.
11. Geochemical Modelling of Secondary Uranium Ore Formation, D. A. Sverjensky.
12. Geochemical Modelling of Present-Day Groundwaters, D. A. Sverjensky.
13. Uranium Sorption, T. D. Waite.
14. Radionuclide Transport, C. Golian and D. A. Lever.
15. Geochemistry of ^{239}Pu, ^{129}I and ^{36}Cl, J. T. Fabryka-Martin.
16. Scenarios, K. Skagius and S. Wingfors.

The ARAP budget, comprising contributions from ARAP participants, is sufficient for all expenses required to complete the project, including the printing and distribution of the 16 final reports. The budget will close out with the completion of ARAP. USDOE will be provided with 50 copies of each report for distribution in the U.S. (this is aside from the copies which will be provided to the USNRC).

Later in the week, a group of ARAP participants and others discussed developing a new program at Koongara. These included ANSTO, JAERI, PNC, CRIEPI (Japan), SKI, USNRC and USDOE. Peter Duerden, ANSTO, has recently been appointed as Nuclear Science representative at the Australian Embassy in Vienna for a period of 3 years, and would not be able to participate in a new program. Wally Zuk, Director of ANSTO's Environmental Science division, stated that ANSTO had already decided to reorganize, and the group that managed the ARAP will no longer exist. Zuk further stated that ANSTO is NOT interested in participation and management of a new large-scale project, similar to ARAP, but would be interested in a low level of participation in a project that uses samples or data collected by ARAP, or that further develops some of the ARAP studies. It was decided that each of the meeting participants would consider their specific interest in further work at Koongara and get back to the other participants early in 1993.

III. FINAL MEETING OF THE JTC OF THE OECD/NEA INTERNATIONAL STRIPA PROJECT AND VISIT TO TVO FACILITIES AT OLKILUOTO, FINLAND.

The official representatives to the Stripa JTC assembled at the Hotel Ramada Presidentii in Helsinki, Finland on Sunday, 11th October, 1992. On the morning of Monday, 12th October, 1992 the 14 assembled participants traveled by bus from Helsinki to the Teollisuuden Voima Oy (TVO) facility at Olkiluoto in southwest Finland. The 14 participants included 9 national representatives from the 7 nations that participated in Phase III of the Stripa Project, a representative from OECD/NEA, the 2 Chairmen of the Stripa Technical Subgroup (TSG), and Stripa's Project Manager and Assistant Project Manager/JTC Secretary.
At Olkiluoto, the JTC members received a briefing on the status of Finland's waste program, examined the exhibits in TVO's Visitors' Center and toured one of the two nuclear power plants (BWRs) operated by TVO. This was followed by a visit to TVO's KPA-STORE, the interim storage facility for spent nuclear fuel. The KPA-STORE remains as it was during my two previous visits in 1989 and 1991.

The JTC then toured the recently completed VLJ repository, Finland's final repository for low and intermediate-level operating nuclear wastes. Excavation of this facility began in 1988 and operations commenced in 1992. The silos are 70-100 meters below the ground surface in migmatitic crystalline rock. The annual accumulation of operating wastes to be stored in the VLJ repository is between 150m^3 and 200m^3. The repository facilities has been constructed to accommodate ca. 8,000m^3 of operating waste in the two silos, and is capable of expansion.

The night of Monday, 12th October, 1992 was spent in the town of Rauma. On the morning of Tuesday, 13th October, 1992, the JTC traveled by bus to the city of Turku, and at the Port of Abo boarded the M/S Silja Festival for transport to Stockholm, Sweden. The Fifteenth and final meeting of the Stripa JTC was held on 13th October, aboard the M/S Silja festival. Per-Eric Ahlstrom, SKB, Sweden, Chairman of the Stripa JTC opened the meeting.

Bengt Stillborg, SKB, Sweden, Stripa Project Manager provided a status of the Overview reports:
- Reports have taken much greater effort than anticipated and were not completed in time to be distributed at the symposium.
- Between January and June, 1992, the review team (Paul Gnirk, Malcolm Gray, and Bengt Stillborg) visited all 7 member countries
- The Executive Summary was distributed by 17th June, 1992
- In July, Malcolm Gray distributed draft Chapters 2, 3, & 4 of the Engineered Barriers Report
- In August, Paul Gnirk distributed a draft of the Natural Barriers Report
- Comments were received from all parties on the Executive Summary Report and the five member team (Gnirk, Gray and Stillborg plus Charles Fairhurst and Ferruccio Gera) met for three weeks to review and revise the reports
- Reports have completed a professional review and edit, and will be sent for final review in ca. 2 weeks
- Volume 2, Natural Barriers will be sent for final review in October. The author, Paul Gnirk, has included Fairhurst's comments and has also revised the report on the basis of comments on the executive summary

- Volume 3, Engineered Barriers: The author, Malcolm Gray, has now completed the revision of Chapters 2, 3, 4 and half of Chapter 5. The remaining part of Chapter 5 plus chapters 1 & 6 remain to be reviewed.

The JTC determined that final review of Volume 1, the Executive Summary, requires completed copies of Volumes 2 & 3 as reference. Therefore, it was promised that Volume 1 would be sent to ALL JTC members by 26th October, Volume 2 would be forwarded by 2nd November, and Volume 3 would be sent by 16th November. All comments must be sent to Bengt by 4th December.

Due to high costs, each JTC representative (2 U.S.) will receive only 10 copies of the Overview Reports plus 1 optical disk. Additional copies will require orders by mid-December plus advance payment (SEK 1,200 per set of overviews plus SEK 2,400 per optical disk). The optical disk includes all Stripa reports plus all Swedish-American Cooperative (SAC) reports.

Final invoices will be received by April 1993. The actual cost of Phase 3 of the Stripa Project fell within the original projection at SEK 144,900,000 (or, estimating an average exchange of US$1.00 = SEK 6.00, ca. US$24,100,000).

Seven technical articles sponsored by the JTC, at a cost of SEK 10,000 each, have been published in peer-reviewed technology journals. Some are still outstanding, however funds are running out (Note: In June 1991, the JTC made available and amount of SEK 100,000 to support the publishing of Stripa papers in peer-reviewed journals). Minutes of the Final Stripa JTC Meeting will be available in December, 1992.

IV. FOURTH INTERNATIONAL SYMPOSIUM ON THE OECD/NEA STRIPA PROJECT

The Fourth International Symposium for the OECD/NEA Stripa Project took place in Stockholm, Sweden Wednesday, 14th October through Friday, 16th October, 1992. It was attended by ca. 180 scientists and technical managers from 18 nations and two international organizations. The Opening Session was Chaired by Edward (Ned) Patera, OECD/NEA, and Hans Carlsson, SGAB International, Sweden.

The Symposium opened by Jean-Pierre Olivier, Head of the Division of Radiation Protection and Waste Management, OECD/NEA, who spoke on the need for geologic disposal as the only practical way of isolating radioactive wastes and the contribution of the Stripa Project to many technical aspects of waste disposal, including PA.

Sten Bjurström, President, SKB, discussed "The Stripa Project in a Swedish Waste Management Perspective". The Stripa Project gave SKB a "flying start" on research in geologic disposal. A "state-of-the-art" approach to R&D was needed in radioactive waste disposal as opposed to normal underground engineering. U.S. participation, which began in 1977, first brought home this lesson to SKB. Siting and development should be an open process to demonstrate to all the safety of the disposal system.

Ken Dormuth, Director, Disposal Technology Division, AECL Research, Canada, spoke on the "Relevance of the International Stripa Project to a National Nuclear Waste Management Program". Stripa complemented R&D work at AECL facilities and led the way in many areas of research. Examples include the buffer mass test and grouting of fractures. In addition there have been a number of Stripa experiments which have been corroborated by work in Canada. These include hydrologic studies using tracers. Stripa studies also permitted the better scheduling of studies at AECL's Underground Research Laboratory.

The technical papers presented in the Fourth Symposium on the International Stripa Project will be published in 1993 as an OECD/NEA volume. As these papers will be available in full text, and full reports on these subjects are already published and widely distributed by the Stripa Project, there is no need to summarize their individual contents. Instead, I list the authors and title of the papers comprising each session. If any reader wishes details of any subject paper, please contact me at DOE in Las Vegas, and I shall be pleased to guide you to the appropriate publication.

Session 1, Natural Barriers - Characterization, Tom Isaacs, USDOE, USA and Hideki Sakuma, PNC, Japan, Chairs, began on Wednesday, 14th October, 1992.
- Olle Olsson, Conterra, Sweden, "The Site Characterization and Validation Program".
- John Gale, Fracflow Consultants, Canada, "Fracture Characterization".
- Nick Barton, Norwegian Geotechnical Institute, Norway, "Stress-dependent Joint Properties".
- Calin Cosma, Vibromatic Oy, Finland, "Borehole Seismics".
- Olle Olsson, Conterra, Sweden, "Borehole Radar".
- John Black and Mark Brightman, Golder Associates, UK, "Hydraulic Characterization".
- Stan Davis, University of Arizona, USA, "Groundwater Chemistry".
- Olle Olsson, John Gale and John Black, "Conceptual Model Development".

Session 1, Natural Barriers - Characterization, resumed on the morning of Thursday, 15th October, Veijo Ryhänen, TVO, Finland and Robert Jackson, UKDoE, UK, Chairs.
- Ivars Neretnieks and Lars Birgersson, Royal Technical Institute (KTH), Sweden, "In-situ Tracer Migrational Experiments".

Session 2, Natural Barriers - Modeling, took place during the late morning and early afternoon of Thursday, 15th October, Ken Dormuth, AECL, Canada, and Bob Levich, USDOE, USA, Chairs.
- Gunnar Gustafson, Chalmers Technical Institute, Sweden, "Site Characterization and Validation Program: Modeling".
- John Gale, "Porous Media Modeling".
- Alan Herbert, UKAEA Harwell, UK, "Discrete Fracture Modeling: NAPSAC".
- Bill Dershowitz, Golder Associates, USA, "Discrete Fracture Modeling: FracMan".
- Jane Long, Lawrence Berkeley Laboratory, USA, "Equivalent Discontinuum Modeling".
- Dave Hodgkinson, Intera, UK, "Model Validation".

Session 3, Engineered Barriers, was held on the afternoon of 15th October, and the morning of 16th October, Robert Lieb, Nagra, Switzerland and Bill Danker, USDOE, USA, Chairs.
- Roland Pusch, Clay Technology AB, Sweden, "Sealing Program".
- Bill Coons, RE/Spec, USA, "Sealing Materials Review".
- Roland Pusch, "Clay Based Materials".
- Maria Onofrei, AECL Research, Canada, "Cement Based Materials".
- Roland Pusch and Lennart Börgesson, Clay Technology AB, Sweden "In-situ Buffer-mass and Sealing Tests".

Session 4, Overview Reporting, took place during the afternoon of Friday, 16th October, Per-Eric Ahlström, SKB, Sweden, Chair.
- Paul Gnirk, Table Top Consultants, USA, "Overview of Natural Barriers".
- Malcolm Gray, AECL Research, Canada "Overview of the Engineered Barriers".
- Charles Fairhurst, University of Minnesota, USA, "Summary Review 1".
- Ferruccio Gera, Ismes S.p.A., Italy, "Summary Review 2".

Session 5, was held the afternoon of 16th October and consisted of a Discussion by an Invited Panel of Experts in the field of Nuclear Waste Management:
- Tom Hunter, Sandia National Laboratories, USA, Chair
- Ken Dormuth, AECL Research, Canada
- Timo Äikäs, TVO, Finland
- Per-Eric Ahlstrom, SKB, Sweden
- Hideki Sakuma, PNC, Japan
- Robert Lieb, Nagra, Switzerland
- Neil Chapman, Intera, UK.

V. INFORMAL DISCUSSION BETWEEN REPRESENTATIVES OF DOE, USA AND PNC, JAPAN

On 16th October, an informal discussion was held with Hideki Sakuma, PNC, Japan, by Bill Danker and Bob Levich, USDOE, USA, concerning potential technical cooperation in the field of nuclear waste management between PNC and USDOE.
- Sakuma stated that the Japanese program is in an R&D phase
- Japan covers only 0.25% of the Earth's surface but has about 10% of the Earth's active volcanoes
- Therefore, because of the high level of tectonic activity, Japan does not intend to place high reliance on natural barriers for their waste disposal program
- Instead, Japan intends to place reliance on very robust engineered barriers and seek natural settings that enhance the performance of these engineered barriers
- Japan is taking a "Site Generic Approach" and is searching for:
  - Favorable geochemistry
  - Tectonic stability
  - Limited risk of disruptive events
  - Low groundwater flux.

PNC has recently produced a generic PA report (PNC-H3) that is currently being translated into English. I agreed to send Kuma a copy of the YMP Bibliography within the next few months, and we both agreed to explore areas for possible technical cooperation between the two programs.

Names of People Contacted - 160 scientists and technical managers from 18 Nations and 3 multinational organizations:

Australia:	Peter Duerden	ANSTO, NSW
	Robert Edis	ANSTO, NSW
	Don Emerson	University of Sydney, NSW
	Cezary Golian	ANSTO, NSW
	Robin Lowerson	ANSTO, NSW
	Tim Payne	ANSTO, NSW
	Lloyd R. Townley	CSIRO, Wembley, WA
	David Waite	ANSTO, NSW
	Karl-Heinz Wyrwoll	Univ. Western Australia, Perth
	Wally Zuk	ANSTO, NSW
Belgium:	Bernard Neerdael	CEN/SCK
	P. Lalieux	ONDRAF/NIRAS, Brussels
Canada:	Ken Dormuth	AECL, Pinawa
	Peter Flavelle	AECB, Ottawa
	John Gale	Fracflow, St. Johns
	Malcolm Gray	AECL, Pinawa
	Lawrence Johnson	AECL, Pinawa
	Doug Metcalfe	AECB, Ottawa
	Maria Onofrei	AECL, Pinawa
	Sid Whitaker	AECL, Pinawa
CEC:	B. Haijtink	CEC, Brussels
	Henning von Maravic	CEC, Brussels
Finland:	Henry Ahokas	Fintact, Helsinki
	Timo Äikäs	Helsinki, Finland
	Pekka Anttila	IVO, Vantaa
	Runar Blomqvist	Geological Survey of Finland
	Calin Cosma	Vibromatic Oy, Perttula
	D. Suksi	University of Helsinki
	Karl-Heinz Hellmuth	STUK, Helsinki
	Heikki Kumpulainen	Tech. Research Cntr., Otakaari
	Veijo Rhyänen	TVO, Helsinki
France:	Paul-Louis Blanc	CEA/IPSN, Fontenay-aux-Roses
	Jacques Boulègue	Université de Paris VI
	Lionel Dewiere	ANDRA, Fontenay-aux-Roses
	P. Escalier Des Orres	CEA/IPSN, Fontenay-aux-Roses
	Jean-Charles Fontes	Université de Paris Sud, Paris
	Emmanuel Ledoux	Ecole des Mines de Paris, Paris
	Francis Lemeille	CEA/IPSN, Fontenay-aux-Roses
	Maria-Theresa Menanger	CEA-CEN, Fontenay-aux-Roses
	J. Brulhet	ANDRA, Fontenay-aux-Roses
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	Bertrand Vignall	ANDRA, Fontenay-aux-Roses

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	Lutz Lidtke	BRG, Hannover
IAEA:	Michael Bell	IAEA, Vienna
Italy:	Ferruccio Gera	ISMES,SpA, Rome
Japan:	Yoshii Kobayashi	JAERI, Tokai
	Takashi Murakami	JAERI, Tokai
	Kimio Miyakawa	CRIEPI, Figeholm, Sweden
	Toshihiko Ohnuki	JAERI, Tokai
	Hideaki Osawa	PNC, Figeholm, Sweden
	Hideki Sakuma	PNC, Tokyo
	K. Sekine	JAERI, Tokai
	Toshihiro Seo	PNC, Tokai
	Kunio Watanabe	Saitama Univ., Saitama
Netherlands:	Rikje van de Weerd	RIVM, Bilthoven
	M. Richardson-van der Pohl	RIVM, Bilthoven
Norway:	Nick Barton	Norwegian Geotechnical Inst.
OECD/NEA:	Claudio Pescatore	OECD/NEA, Paris
	Edward Patera	OECD/NEA, Paris
	Jean-Pierre Olivier	OECD/NEA, Paris
Russia:	Lev Abramovich Pevzner	Superdeep Drilling Co, Yaroslavl
South Korea:	Yoong Soo Hwang	KAERI, Daeduk-Danji
	Sang Kyu Lee	Korea Inst/Geology, Yusongku
	Chan Goo Rhee	KAERI, Daekuk-Danji
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	Carmen Bajos Parada	ENRESA, Madrid
	Jordi Bruno	MTB, Barcelona
	J. Carrera	U.P. de Cataluña, Barcelona
	Carlos Del Olmo	ENRESA, Madrid
	R. Gavela	CIEMAT, Madrid
	Juan C. Mayor	ENRESA, Madrid
	Modesto Montoto	Univ. of Oviedo, Oviedo
	Aurelio Ulibarri	ENRESA, Madrid
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	Per-Eric Ahlstrom	SKB, Stockholm
	Karl Erik Almén	SKB, Stockholm
	Johan Andersson	SKI, Stockholm
	Sten Bjurström	SKB, Stockholm
	Göran Bäckblom	SKB, Stockholm
	Lennart Börgesson	Clay Technology, Lund
	Hans Carlsson	SGAB International, Stockholm
	Torsten Eng	SKB, Stockholm
	Lars Olof Ericsson	SKB, Stockholm

Sweden:	Joel Geier	Golder Geosystem, Uppsala
	Bertil Grundfelt	Kemakta, Stockholm
	Gunnar Gustafson	Chalmers TH, Göteborg
	Fred Karlsson	SKB, Stockholm
	Fritz Kautsky	SKI, Stockholm
	Ivars Neretnieks	KTH, Stockholm
	Lars Bertil Nilsson	SKB, Stockholm
	Sören Norrby	SKI, Stockholm
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	Gunnar Ramqvist	Eltekno AB, Kopparberg
	Invar Rehn	VBB V Iak, Göteborg
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	Roy Stanfors	Consultant, Lund
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	Anders Ström	SKB, Stockholm
	Christer Svemar	SKB, Stockholm
	Olof Söderberg	KASAM, Stockholm
	Öivind Toverud	SKI, Stockholm
	Peter Wikberg	SKB, Stockholm
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	Rudi Beck	Oberwangen
	E. Frank	HSK
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	Ian G. McKinley	Nagra, Wettingen
	Linda McKinley	Nagra, Wettingen
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	Gow-Tay Chyr	Taiwan Power Company, Taipei
	Wen-Chung Liu	Atomic Energy Council, Taipei
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	David Bennett	W.S. Atkins, Epsom
	John Black	Golder Associates, Edwalton
	Kevin Butter	UKDoE-HMIP
	G.S. Boulton	University of Edinburgh
	Neil A. Chapman	INTERA, Melton Mobray
	Alan Herbert	UKAEA-Harwell
	David Hodgkinson	Intera, Henley-on-Thames
	Robert Jackson	UKDoE, London
	Paul J. Hooker	BGS-Nottingham
	Miro Ivanovich	UKAEA-Harwell
	David A. Lever	UKAEA-Harwell
	Anna Littleboy	UK Nirex, Harwell
	William Miller	INTERA, Melton-Mobray
	Robert Muir-Wood	BEQE, Clapton
	David Read	W.S. Atkins, Epsom
	Cherry Tweed	AEA Technology-Harwell

USA:	Steve Alcorn	RE/SPEC, Albuquerque
	George Barr	SNL, Albuquerque
	Bill Coons	RE/SPEC, Albuquerque
	Dave Curtis	LANL, Los Alamos
	Bill Danker	USDOE, Washington DC
	Jack Daemen	University of Nevada, Reno
	Bill Dershowitz	Golder Associates, Seattle
	Stan Davis	University of Arizona, Tuscon
	Holly Dockery	SNL, Albuquerque
	Tom Doe	Golder Associates, Seattle
	Norm Eisenberg	USNRC, Washington DC
	Rod C. Ewing	Univ. of New Mexico, Albuquerque
	June Fabryka-Martin	LANL, Los Alamos
	Charles Fairhurst	Univ. of Minnesota, Minneapolis
	Craig Garven	Johns Hopkins Univ., Baltimore
	Bill Glassley	LLNL, Livermore, CA
	Paul Gnirk	Table Top Consult., Rapid City
	Ray Godman	TRW, Vienna
	Tom Hunter	SNL, Albuquerque
	Tom Isaacs	USDOE, Washington DC
	Linda A. Kovach	USNRC, Washington DC
	Jane Long	LBL, Berkeley
	William M. Murphy	SWRI, San Antonio
	Claudia Newbury	USDOE, Las Vegas
	D. Kirk Nordstrom	USGS, Denver
	John L. Smoot	Battelle PNL, Richland
	Dimitri A. Sverjensky	Johns Hopkins Univ., Baltimore